NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 3-94

EVALUATION OF OXYGEN LEVELS WITHIN THE DIVING UNLIMITED INTERNATIONAL (DUI) PASSIVE THERMAL SURVIVAL SYSTEM

LT K.L. RUSSELL

SEPTEMBER 1993

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:
NAVSEA TA92-014/92-015

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 3-94

EVALUATION OF OXYGEN LEVELS WITHIN THE DIVING UNLIMITED INTERNATIONAL (DUI) PASSIVE THERMAL SURVIVAL SYSTEM

LT K.L. RUSSELL

SEPTEMBER 1993

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

Submitted:

K.L. RUSSELL
LT, MC, USNR
Research Medical Officer

Reviewed:

M.E. KNAFELC
CDR, MC, USN
Senior Medical Officer

D.J. SCHMITT
Ocean Engineering
Department Head

B.D. MCKINLEY
LCDR, USN
Senior Projects Officer

J.R. CLARKE
Scientific Director

M.V. LINDSTROM
LCDR, USN
Executive Officer

Approved:

BERT MARSH
CDR, USN
Commanding Officer

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU REPORT NO. 3-94	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION NAVY EXPERIMENTAL DIVING UNIT; 6b. OFFICE SYMBOL (If applicable) 02	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS(City, State, and ZIP Code) Panama City, FL 32407-5001	7b. ADDRESS(City, State, and ZIP Code)
8a. NAME OF FUNDING SPONSORING ORGANIZATION NAVAL SEA SYSTEMS COMMAND; 8b. OFFICE SYMBOL (If applicable) OOC	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Washington, D.C. 20362-5101	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. 92-014 /92-015 / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
(U) Evaluation of Oxygen Levels Within The Diving Unlimited International (DUI) Passive Thermal Survival System

12. PERSONAL AUTHOR(S)
LT K. L. Russell

13A. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year,Month,Day)	15. PAGE COUNT
Test Report	FROM APR 93 TO MAY 93	September, 1993	13

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Passive thermal survival systems, oral-nasal, oxygen levels, Diving Unlimited International (DUI)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Various studies have been performed on the Diving Unlimited International passive thermal survival systems. The sample size in all of these studies was limited to only one or two subjects. Furthermore, oxygen levels within the oral-nasal were generally not addressed. The design characteristics of the DUI system has raised concern that adequate levels of oxygen may not be provided for the diver. The DUI system was tested at 36 fsw (simulating the partial pressure of oxygen in a U.S. Navy saturation diving system) with fifty subjects to evaluate the trends of oxygen within the oral-nasal mask.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
[ ] UNCLASSIFIED/UNLIMITED [X] SAME AS RPT. [ ] DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE(Include Area Code)	22c. OFFICE SYMBOL
NEDU Librarian	904-230-3100	

ITEM #19 (continued):

Two of fifty subjects (4%) had oral-nasal oxygen levels that decreased to less than the termination criteria of 14% (.14 ATA). From the binomial, this represents a 95% confidence interval of 0.5 to 14%. Other subject's oxygen decreased, but stabilized at higher levels. The effect of various maneuvers in increasing or maintaining the oxygen levels within the system was evaluated. A series of five long, deep breaths was most effective in raising oxygen levels. Other maneuvers, such as "fluffing" or taking the canister out of the bag, were less effective and also had the disadvantage of adversely affecting the passive thermal aspects of the system. Presumably, oxygen levels fell due to the increased dead space created by the "to-fro" design of the system. In conclusion, the use of the DUI system with the 5 deep breath maneuver will greatly decrease the risk of hypothermia in an emergency situation.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

Hyperbaric passive thermal survival systems have been developed to minimize core temperature heat loss in the event of loss of power to a hyperbaric chamber or personnel transfer capsule ("Lost Bell" scenario). One such system, the Diving Unlimited International (DUI), has been investigated at Navy Experimental Diving Unit.[1] The design of this system raised concern that adequate levels of oxygen may not be provided for the diver.

Various studies have been performed on this system in the last decade by other institutions. The ability of the system to thermally protect divers in a simulated "lost bell" scenario was documented, but oxygen available to the divers was generally not addressed. Only one of these studies, Polar Bear III, clearly documents the O_2 level in the oral-nasal mask. In this study, the O_2 level decreased at 150 msw, but was maintained above 0.20 ATA (20.2 kPa).[2] At no time during these studies were symptoms of hypoxia documented, but the sample size was limited to only one or two subjects per study.

Initial experiments with the DUI system at NEDU confirmed that adequate oxygen levels may not always be provided by the DUI oral-nasal mask. In the first of various studies, subjects donned the DUI system on the surface (0.21 ATA PO_2). O_2 and CO_2 levels in the oral-nasal mask were monitored. During this study, the peak inspired PO_2 level decreased to less than 16% within 4 minutes for 3 of the 4 subjects.

Next, the system was tested in a 0.44 ATA PO_2 environment (36 fsw, 11.16 msw) simulating the minimum partial pressure of oxygen in a U.S. Navy saturation diving system.[3] For all 4 subjects, the mask PO_2 level quickly decreased to 25% (0.25 ATA). In 2 subjects the PO_2 decreased to less than 20% (0.2 ATA), with one continuing to less than 14% (0.14 ATA), necessitating removal of the oral-nasal mask. Because of that one observed failure, the present study was designed to assess the reliability of the DUI Passive Thermal Survival System by duplicating the scenario in which the failure occurred.[4]

MATERIALS

DUI SYSTEM (APPENDIX A)

-- Synthetic non-absorbent vacuum packed sleeping bag backed with noncompressible insulation.

-- Thermal regenerator/CO2 scrubber, consisting of an oral-nasal mask attached to a soft canister via a single corrugated plastic hose (thus a "to-fro" action).

-- One-piece Thinsulate coverall including foot coverage.

METHODS

GENERAL

Nylaflow capillary tubing (0.20 cm inside diameter) was used for gas sampling of the oral-nasal mask PCO_2, PO_2, and chamber PO_2. Breath-to-breath analysis of oral-nasal gases was performed with an Extrel Mass Spectrometer (Extrel Corporation, Pittsburgh PA). Trending PO_2 data was continuously monitored with Rosemount Oxygen Analyzer Model 755A (Beckman, Fullerton CA). Sampling and logging rates for breath-to-breath analysis was 35 Hz, and logging of trending data was every 10 seconds.

Forty-eight subjects were planned to give a 95% reliability with a 90% confidence level for the DUI system, if there were no failures. Eight diver-subjects, composed of two teams of four, entered Echo and Delta chambers of the Ocean Simulation Facility (OSF) at one time. The chambers were then compressed to 36 fsw. Chamber PO_2 was maintained at $0.44 \pm .02$ ATA. The DUI soft scrubbers were pre-filled with approximately 2.95 kg of Sofnolime (4-8 mesh size). The first team, wearing UDT's and tee-shirts, entered their respective DUI systems with the remaining divers acting as tenders. Subjects were asked to lie in a supine position and remain awake. Once all subjects were within their systems, the oral-nasal masks were donned simultaneously. This started "zero time." Attempts were made to cool the chamber to a comfortable level, but a cooling profile was not performed.

Diver-subjects were to remain at rest in the system for a maximum of 30 minutes or until termination criteria were met[4]. Prior to removal of the system, the subjects were requested to perform one or more maneuvers to evaluate their effect in raising the PO_2 within the oral-nasal mask. The maneuvers performed were:

1. Fluffing the sleeping bag
2. Taking a series of long, deep breaths
3. Taking the canister out of the sleeping bag and laying it on top
4. Disconnecting the corrugated tube (used to attach the oral-nasal mask to the soft scrubber) at the point of the soft scrubber

"Fluffing" was performed by having the subject push out on the sleeping bag from inside with his/her arms and hands in an attempt to "pull" fresh air into the interior of the sleeping bag system. The combination of maneuvers performed by subjects were as follows:

1.	Fluffing alone	4 subjects
2.	Fluffing followed by deep breathing	12 subjects
3.	Deep breathing alone	4 subjects
4.	Deep breathing followed by fluffing	14 subjects
5.	Canister out of sleeping bag	10 subjects
6.	Canister out followed by tube disconnect	4 subjects

When two maneuvers were performed by the same subject, time was allowed for a new baseline to be established before the second maneuver was performed. Subjects were asked to remove the mask if PO_2 levels within the oral-nasal mask fell to less than 16% (0.16 ATA) for greater than one minute, or 14% (0.14 ATA) at any time. If termination was required based on oral-nasal oxygen levels, maneuvers were not performed.

Upon completion of each run, the oral-nasal masks were cleaned with Betadine, and team two began donning the systems with team one acting as tenders. The same protocol was performed by the second set of four divers. When all divers completed the DUI breathing period, the chambers were surfaced and another two teams of four divers began preparing for press. The Sofnolime in the soft canisters was changed each day, but not between runs.

After the dive series, modified pulmonary function testing was performed by the subjects. These were obtained by having the subjects lie in the DUI sleeping bag system with a brick on their chest (simulating the weight of the canister) for ten minutes while breathing into a Collins Pneumotach Spirometer (Warren E. Collins, Inc., Braintree, MA). The tidal volume while at rest was measured as well as the tidal volume during a series of slow deep breaths. This was followed by a questionnaire [Appendix (B)].

DATA ANALYSIS

A total of 52 subjects participated. Two were not included in data analysis; one because of a loose connection, and one due to spilling of the Sofnolime into the sleeping bag. In analysis of the data, trending oral-nasal PO_2 was used. The **low** PO_2 encountered in the two minutes preceding a maneuver was compared with the **high** PO_2 during the two minutes after, and the difference in the PO_2 was calculated.

Baseline PO_2 levels during the runs did fluctuate, therefore a positive PO_2 difference would inevitably be found. A control was therefore performed on all the subjects. The low two minutes before, and high two minutes after the twenty minute mark was derived, and difference calculated. This control average was compared to the effect of maneuvers in the statistical analysis of the data.

Some initial questions had to be answered before proceeding to the final analysis.

1. When fluffing was done alone, as compared to before or after deep breathing, was the effect on the oral-nasal PO_2 significantly different? The same question needed to be answered with regard to deep breathing. If there was not a significant difference, the maneuvers could be pooled.

2. Did a low pre-maneuver PO_2 level result in a larger increase in oral-nasal PO_2? If it did, and one group generally started at a lower PO_2 level, then an unfair advantage would be given that group.

3. Did each group of maneuvers start from statistically similar pre-maneuver oral-nasal PO_2 levels?

The modified tidal volumes were used to evaluate if any relationship could be found between the air moved by the subjects, and the resultant decline in PO_2.

RESULTS

Data, including change in PO_2 with maneuvers, change in PO_2 with control, and values from the pulmonary studies, is found in Appendix C. Figure 1 is a scattergram of the minimum percent oxygen encountered in all of the trials. Remember the PO_2 in the atmosphere the subjects were exposed to was 44% SEV (0.44 ATA). As can be seen, two subjects' PO_2 fell below 14% (0.14 ATA), necessitating termination of their run. For one of these subjects, the PO_2 fell to 11.42% (0.114 ATA) briefly before levels began to increase. No symptoms of hypoxia were reported by any of the subjects. Based on the termination criteria, there was a 4% failure rate.

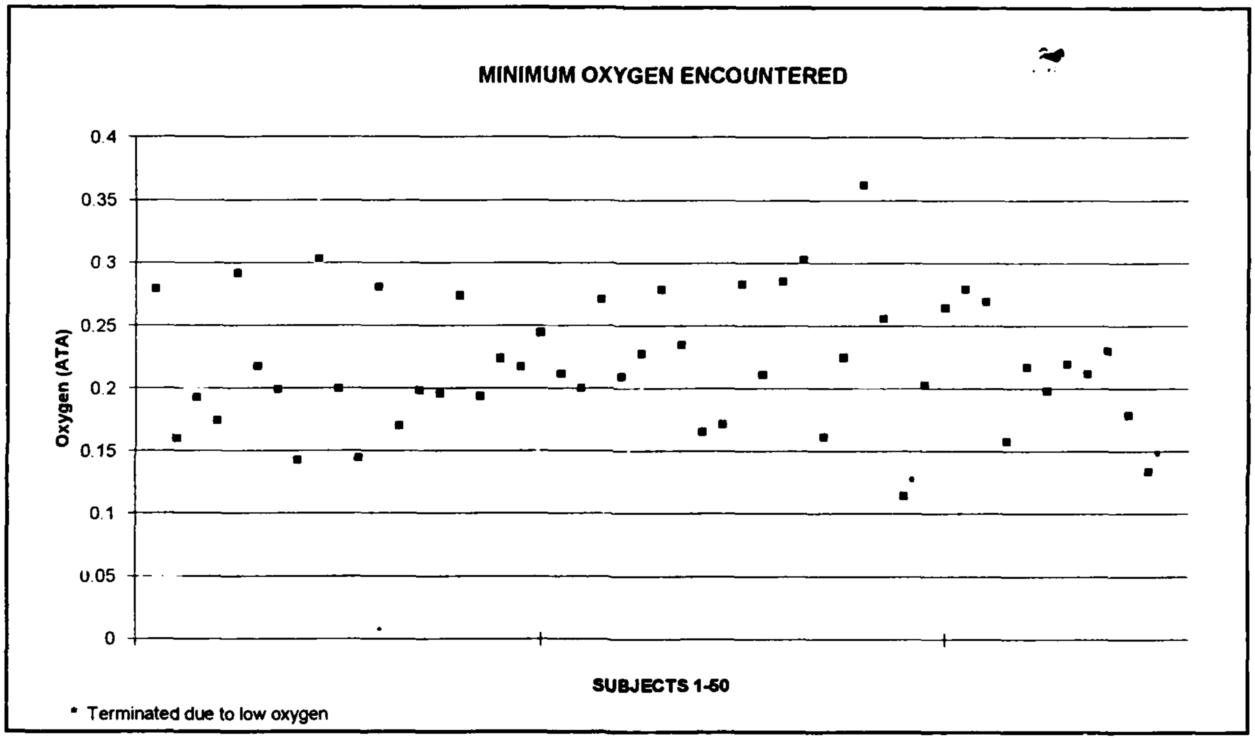

Figure 1. Minimum oxygen level encountered in each of fifty runs.

However, due to the limited number of subjects, the binomial 95% confidence limits on that 4% failure rate range from 0.5% to 14%. Analysis of variance revealed that whether fluffing was performed alone, before deep breathing, or after deep breathing, the effect on the oral-nasal oxygen was not significantly different. Deep breathing was similarly not influenced by fluffing. Therefore, all fluffing was pooled, regardless of when performed, and all deep breathing was pooled. The result was 5 different groups to use in statistical analysis:

1. Deep breathing n=30
2. Fluffing n=30
3. Canister out n=14
4. Tube disconnected n=4
5. Control n=48

Disconnecting the corrugated tubing from the soft CO_2 canister (which was already outside the sleeping bag) resulted in an increase in oral-nasal PO_2 to a level approximately 4% below chamber PO_2 regardless of the original oral-nasal PO_2. Presumably, this was due to the increased dead space, 250 ml, provided by the mask and corrugated tubing.

The effect of the pooled deep breathing, fluffing, and canister out of the sleeping bag maneuvers was analyzed. Figure 2 illustrates the relationship between these three maneuvers and their respective controls. The average PO_2 increase was 8.00% SEV for deep breathing, 3.97% for fluffing, and 5.66% for canister out of the bag. Deep breathing and canister out of the bag were significantly different than control, but fluffing was not. Deep breathing was also significantly different than fluffing, but not canister out of the bag.

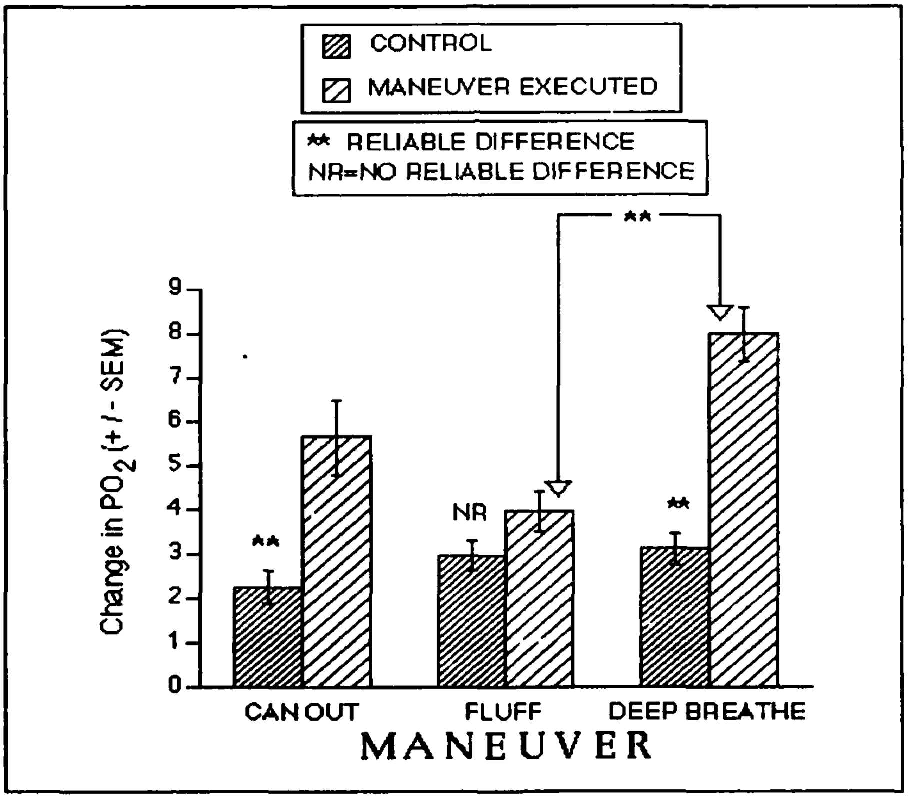

Figure 2. Comparison of maneuvers on oxygen levels, with respective controls

Linear regression analysis of pre-maneuver oxygen levels and change in oxygen revealed a reliable relationship between the two variables ($r^2 = 0.216$; $p < 0.0001$). Thus, lower initial PO_2 levels resulted in a greater change in oxygen levels. When the maneuver that had the greatest increase in PO_2 (deep breathing) was independently analyzed, a much tighter fit was found ($r^2 = 0.658$; $p < 0.0001$). Compare this to the independent analysis of fluffing ($r^2 = 0.168$; $p = 0.0243$). It makes sense that a tighter fit would be found with the maneuver that is best at actually changing the PO_2.

To make sure that no maneuver strategy had an advantage by starting at lower PO_2 levels, the pre-maneuver oxygen levels in all five groups were analyzed for variance. No relationship was found. Therefore, no group had the advantage of higher changes based on lower pre-maneuver oxygen levels.

No relationship was found between the subjects' resting tidal volumes after the study and the minimum PO_2 encountered during their runs. There was also no relationship between the amount of air the subjects moved with deep breathing, and the increase in PO_2 noted with the deep breathing maneuver. This is a counter-intuitive result. Admittedly, the pulmonary studies performed on the subjects were done at a later time. Instrumentation was not available to evaluate the actual volume of air moved by the subjects during the study at depth.

DISCUSSION

There are several theories for depressed O_2 levels within the DUI system. One is that fresh, oxygen rich air "diffuses" poorly into the sleeping bag system where the soft canister was located. Therefore, the "air" to which the canister was exposed would become progressively oxygen poor. Another proposed mechanism involves the system dead space. As Appendix. A illustrates, the DUI system has a single corrugated tube which connects the oral-nasal mask to the soft CO_2 scrubbing canister resulting in a "to-fro" action. This results in a large amount of exhaled air being rebreathed at the beginning of each breath. Although this rebreathed air would be adequately scrubbed of CO_2, O_2 levels could be inadequate depending on breathing patterns. The warm, supine, quiet atmosphere relaxed the subjects, resulting in shallow breaths. Subjects often had difficulty staying awake.

Fluffing and removing the canister from the sleeping bag are maneuvers likely to result in diminished passive thermal protection. Deep breathing is less likely to do so. Deep breathing, as noted above, was also the maneuver which increased the oral-nasal PO_2 levels the most, short of disconnecting the soft canister from the corrugated tubing.

Attempts were made to correlate subjects' breathing patterns with the minimum PO_2 each encountered in their runs, as well as the ability to increase oxygen within the oral-nasal masks with deep breaths. The subjects, at a later time, were put in a situation that attempted to replicate the study conditions: a quiet, warm, comfortable position. It was felt that this environment could encourage shallow breathing. The inability to find any relationship could be because the original environment was not accurately simulated, or because of intrasubject variation. Ideally, air moved by the subjects during the study, not at a later time, should have been measured. Unfortunately, the required instrumentation was not available.

Taking the canister out of the sleeping bag caused a significant change in oral-nasal PO_2, but was this actually a result of the new oxygen rich atmosphere to which the canister was exposed? If that was the reason for the increase, one would have expected fluffing to have a similar increase. A more likely explanation would be that in the process of getting the canister out of the sleeping bag, the subjects naturally increased their breathing pattern, thus breathing past the dead space.

The dramatic rise with removal of the corrugated tubing suggests that the increased dead space of the canister was the largest contributing factor to the low oral-nasal PO_2 levels. Since deep breathing had a significant effect when the canister was within the bag, it supports the hypothesis that increases in tidal volume beyond the dead space volume are necessary to maintain adequate oxygen levels within the DUI soft scrubber system.

CONCLUSIONS

Four percent (2/50) of the subjects in this study failed to maintain oral-nasal oxygen levels above 14% SEV in a 0.44 ATA atmosphere. The result of 2 failures out of 50 trials is consistent with a true failure rate as high as 14%. Various maneuvers were evaluated for their effect in raising the PO_2 level within the oral-nasal mask. The maneuver which had the largest effect was a series of long deep breaths, which also has the advantage of not greatly compromising the passive thermal aspects of the system.

The most likely cause of decreased oral-nasal oxygen levels is the dead space of the to-fro design. However, some aspect of decreased circulation into the sleeping bag, causing a depleted oxygen source around the CO_2 scrubber, cannot be ruled out by this study.

The thermal advantages provided by the Diving Unlimited International passive thermal survival system have been shown previously.[5] It is felt that this system is safe for use if subjects take a series of 5 long, deep breaths regularly while in the system. Based on the rate of decrease of O_2 in the system, every 5 minutes is a reasonable interval. This would decrease the risk of dangerous hypoxia without seriously compromising the thermal efficiency of the system.

REFERENCES

1. NEDU ltr 3963/TA91-007 Ser 0724/010 of 3 January 1992.

2. S. Tonjun, et al., *Polar Bear III, Norwegian Underwater Technology Center*, Report 21-82, 26 January 1982.

3. P. C. Kelleher, *Evaluation of the Diving Unlimited International (DUI) Hyperbaric Passive Thermal Protection System: Inspired Oxygen Levels at 36 FSW (0.44 ATA PO_2)*, NEDU TM 92-14, Navy Experimental Diving Unit, 16 June 1992 (Limited Distribution).

4. K. L. Russell, *Manned Evaluation of DUI Hyperbaric Passive Thermal Protection System at 0.44 ATA PO_2 in Nitrogen (Manned)*, NEDU TP 93-16, Navy Experimental Diving Unit, 26 April 1993 (Limited Distribution).

5. K. L. Russell, *Evaluation of the KIN and DUI Passive Thermal Survival System: Deep Dive 92*, NEDU TR 4-93, Navy Experimental Diving Unit, April 1993.

DUI POLAR BEAR II

Three years of testing, research and real world experience brought out a number of problems experienced by all known bell survival systems. DUI has effectively addressed these problems in the Polar Bear II system.

SYSTEM COMPONENTS

SLEEPING BAG CONSTRUCTION

- All plastic Delrin non-corrosive zippers and slides
- Thinsulate insulation reduces water ingress providing excellent insulation qualities.
- The M4 non-compressible insulation in the back of the sleeping bag eliminates the mattress and the need to rely on air filled devices.
- Narrow leg and foot section design reduces gas pumping.

THE COVERALL

- One piece Coverall provides total body protection during bell cool down and set up while operating valves or communications equipment.
- Can be used in deck chambers and life boats.
- Designed for simple immediate use.

PACKAGING

- Reduced size
- Eliminated mattress tube
- Easier opening

NEW DUI SOFT CO^2 SCRUBBER

DUI® INC

SOFT DESIGN ADVANTAGE - Soda Sorb can be further activated by pounding on the soft canister with the palms of the hands to increase use time.

COMFORT/SIMPLICITY - The mask, with its pull-tab adjustments, offers extreme comfort including a new canister support design which places the canister weight on the neck.

VERSATILITY - Only the DUI System can be used in a high CO^2 atmosphere.

PACKING KNOWLEDGE - Canister can be filled easily, by the unfamiliar, and our unique compression system insures against channeling.

EASY FILL DESIGN - Canister can be sent down empty with separate supply of Soda Sorb, filled at the surface, or during the dive. Either with a fraction of the time previously needed.

CANISTER VOLUME - The new soft canister can hold 6½ plus pounds.

O^2 DEAD SPACE - Because of the unique to/fro design and large surface area the O^2 and CO^2 dead space has been minimized. The Dwell Time in the Bed has been increased dramatically.

DIVING UNLIMITED INTERNATIONAL, INC.
1148 Delevan Drive • San Diego, CA 92102 • Phone: (619) 236-1203 • Telex: 697971

DUI LIMITED • Advance Unit 8
Farburn Industrial Est • Dyce, Aberdeen • Phone: (224) 724093 • Telex: 739130

APPENDIX B

DATE: 28-29 APRIL 1993

QUESTIONNAIRE FOR DUI O_2 STUDY

Lost PTC Scenario, Passive Thermal Survival Systems

Diver's Name:____________________________

1. HOW WAS THE FIT OF THE ORONASAL MASK?

1 2 3 4 5 6 7 8 9 10

Very Uncomfortable — Most Comfortable

COMMENTS:

2. HOW MUCH BREATHING RESISTANCE DID YOU EXPERIENCE WITH THE UNIT?

1 2 3 4 5 6 7 8 9 10

NONE — UNABLE TO BREATHE

COMMENTS:

3. DID YOU FIND THE WEIGHT OF THE CANISTER ON YOUR CHEST UNCOMFORTABLE?

1 2 3 4 5 6 7 8 9 10

NO — VERY

COMMENTS:

4. DID YOU EXPERIENCE ANY UNUSUAL FEELINGS OR SYMPTOMS? EXPLAIN:

5. ANY OTHER COMMENTS ON THE USE OF THE SYSTEM?

APPENDIX C

DUI ORAL-NASAL OXYGEN STUDY

NAME	COLOR	MINIMUM	CONTROL LOW	CONTROL HIGH	CHANGE CONTR	MANEUVERS	LOW BEFORE	HIGH AFTER	CHANGE P02	TIDAL VOLUME	TIDAL VOLUME
		%PO2	%PO2	%PO2	%PO2	AT END	MANEUVER %PO2	MANEUVER %PO2	W/MANEUVER	RESTING	DEEP BREATHS
D1R1	RED	27.88	28.94	29.81	0.87	FLUFF	30.36	33.09	2.73	0.55	3.57
D2R1	GREEN	15.96	17.6	20.87	3.27	FLUFF	18.7	24.41	5.71	0.83	3.13
D3R1	YELLOW	19.23	19.74	23.71	3.97	FLUFF	22.36	27.06	4.7	1.39	5.2
D4R1	ORANGE	17.41	20.26	22.99	2.73	FLUFF	17.78	22.03	4.25	0.8	3.78
D1R2	RED	29.15	29.67	32.27	2.6	FLUFF	29.46	35.08	5.62	1.01	3.24
						DEEP BR	30.23	37.48	7.25		
D2R2	GREEN	21.71	26.25	31.4	5.16	FLUFF	32.03	33.6	1.57	0.82	2.17
						DEEP BR	32.77	36.24	3.47		
D3R2	YELLOW	19.9	21.96	23.35	1.39	FLUFF	19.9	29.23	9.33	1.3	3.41
						DEEP BR	25.3	29.89	4.59		
D4R2	ORANGE	14.26	15.72	18.86	3.14	FLUFF	15.15	17.11	1.96	1.11	5.48
						DEEP BR	15.47	30.11	14.64		
D1R3	RED	30.29	31.57	34.05	2.48	FLUFF	30.29	34.26	3.97	0.73	5.31
						DEEP BR	32.51	35.94	3.43		
D2R3	GREEN	19.96	22.28	27.16	4.88	FLUFF	19.96	26.54	6.58	1.07	3.28
						DEEP BR	23.17	31.97	8.8		
D3R3	YELLOW	14.44	15.48	21.87	6.39	FLUFF	15.5	27.94	12.44	2.07	5.9
						DEEP BR	22.67	29.82	7.15		
D4R3	ORANGE	28.04	28.55	31.01	2.46	FLUFF	28.8	30	1.2	0.81	4.35
						DEEP BR	29.19	34.66	5.47		
D1R4	RED	16.98	20.25	21.06	0.81	FLUFF	16.98	20.69	3.71	0.54	4.5
						DEEP BR	19.38	30.71	11.33		
D2R4	GREEN	19.82	20.87	22.18	1.31	FLUFF	19.82	24.38	4.56	1.07	2.5
						DEEP BR	22.76	29.2	6.44		
D3R4	YELLOW	19.54	19.54	23.5	3.96	FLUFF	33.31	36.59	3.28	0.68	4.46
						DEEP BR	33.97	35.15	1.18		
D4R4	ORANGE	27.36	29.56	31.88	2.32	FLUFF	27.57	33.01	5.44	0.85	5.18
						DEEP BR	29.94	34.99	5.05		
D1R5	RED	19.34	19.87	21.57	1.7	DEEP BR	20.33	34.73	14.4	0.94	3.54
D2R5	GREEN	22.37	22.64	25.42	2.78	DEEP BR	23.35	34.01	10.66	0.75	6.86
D3R5	YELLOW	21.66	24.23	31.15	6.92	DEEP BR	30.65	37.95	7.3	1.04	4.94
D4R5	ORANGE	24.4	25.16	29.04	3.88	DEEP BR	25.4	33.19	7.79	0.9	2.05
D2R6	GREEN	21.11	21.41	22.64	1.23	CAN OUT	22.64	25.86	3.22	0.87	2.93
D3R6	YELLOW	19.99	19.99	25.8	5.81	CAN OUT	23.65	29.31	5.66	0.74	4.52
D4R6	ORANGE	27.06	27.74	30.1	2.36	CAN OUT	27.31	33.78	6.47	0.93	2.26
D1R7	RED	20.93	22.91	26.82	3.91	DEEP BR	20.93	30.69	9.76	0.8	4.02
						FLUFF	23.69	25.47	1.78		
D2R7	GREEN	22.77	25.56	33.64	8.08	DEEP BR	28.96	36.39	7.43	0.85	3.3
						FLUFF	29.6	32.94	3.34		
D3R7	YELLOW	27.83	29.19	33.17	3.98	DEEP BR	27.83	32.92	5.09	0.87	4.15
						FLUFF	29.7	33.44	3.74		
D4R7	ORANGE	23.46	26.94	28.75	1.81	DEEP BR	24.9	30.48	5.58	0.64	4
						FLUFF	25.52	26.91	1.39		
D1R8	RED	16.56	16.68	20.57	3.89	CAN OUT	16.82	24.04	7.22	1.17	3.9
						TUBE OFF	23.33	40.29	16.96		
D2R8	GREEN	17.15	16.97	18.57	1.6	CAN OUT	20.78	25.26	4.48	0.85	2.99
						TUBE OFF	21.33	38.59	17.26		
D3R8	YELLOW	28.3	29.72	30.87	1.15	CAN OUT	29.56	33.63	4.07	0.57	3.05
						TUBE OFF	32.05	38.91	6.86		
D4R8	ORANGE	21.05	21.05	23.91	2.86	CAN OUT	21.78	25.54	3.76	0.46	2.76
						TUBE OFF	24.52	36.24	11.72		

APPENDIX C

DUI ORAL-NASAL OXYGEN STUDY (Continued)

D1R9	RED	28.51	32.04	37.04	5	DEEP BR	29.59	37.06	7.47	1.09	3.72
						FLUFF	31.48	33.5	2.02		
D2R9	GREEN	30.25	32.07	33.02	0.95	DEEP BR	31.56	37.55	5.99	1.47	3.9
						FLUFF	33.76	35.2	1.44		
D3R9	YELLOW	16.13	17.62	19.14	1.52	DEEP BR	17.3	26.9	9.6	0.55	4.41
						FLUFF	20.3	21.6	1.3		
D4R9	ORANGE	22.48	23.33	26.13	2.8	DEEP BR	22.65	32.21	9.56	0.41	3.97
						FLUFF	25.07	26.4	1.33		
D1R10	RED	36.21	36.98	38.17	1.19	CAN OUT	37.35	38.8	1.45	0.87	4.57
D2R10	GREEN	25.54	29.18	31.86	2.68	CAN OUT	26.4	32.19	5.79	0.85	2.94
D3R10	YELLOW	11.42	NA	NA			TERMINATED	LOW O2		0.53	2.25
D4R10	ORANGE	20.23	23.44	25.24	1.8	CAN OUT	23.13	25.1	1.97	1.13	4.14
D1R11	RED	26.41	26.95	31.4	4.45	DEEP BR	26.41	36.75	10.34	0.65	4.09
						FLUFF	27.5	32.64	5.14		
D2R11	GREEN	27.9	31.01	32.7	1.69	DEEP BR	30.78	36.15	5.37	1.72	4.59
						FLUFF	28.14	33.06	4.92		
D3R11	YELLOW	26.93	27.56	28.98	1.42	DEEP BR	27.54	34.93	7.39	0.53	1.26
						FLUFF	30.02	32.11	2.09		
D4R11	ORANGE	15.75	17.63	20.11	2.48	DEEP BR	15.75	27.21	11.46	0.88	2.71
						FLUFF	22.6	24.53	1.93		
D1R12	RED	21.69	26.2	27.32	1.12	CAN OUT	21.69	28.43	6.74	0.46	2.49
D2R12	GREEN	19.78	22.33	22.84	0.51	CAN OUT	20.69	33.49	12.8	1.21	5.51
D3R12	YELLOW	21.94	27.49	30.36	2.87	CAN OUT	30.73	35.47	4.74	0.76	4.67
D4R12	ORANGE	21.17	22.33	24.91	2.58	CAN OUT	22.3	33.11	10.81	0.97	3.13
D1R13	RED	23.01	24.87	26.91	2.04	DEEP BR	25	36.84	11.84	0.83	4.14
						FLUFF	28.35	33.62	5.27		
D2R13	GREEN	17.88	20.77	21.91	1.14	DEEP BR	18.08	32.14	14.06	0.6	2.76
						FLUFF	23.53	29.94	6.41		
D3R13	YELLOW	13.4067	NA	NA			TERMINATED	LOW O2		0.68	2.47